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LABORATORY LEAFLETS
FOR
QUALITATIVE ANALYSIS

BY

LULA GAINES WINSTON, Ph. D.
(Johns Hopkins University)
(Professor of Chemistry at Meredith College, Raleigh, N. C.)

THE CHEMICAL PUBLISHING CO.,
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REACTIONS

(Complete and balance, underscoring precipitates.)

GROUP I.

LEAD Pb^{II}

1. $Pb(NO_3)_2 + HCl \rightleftharpoons$
2. $PbCl_2 + H_2O \text{ (hot)} \rightleftharpoons$
3. $PbCl_2 + H_2S \rightleftharpoons$
4. $PbCl_2 + H_2SO_4 \rightleftharpoons$
5. $PbCl_2 + K_2Cr_2O_7 + (\quad) \rightleftharpoons \underline{Pb\ CrO_4} + H_2CrO_4 + (\quad)$

SILVER Ag^I

1. $AgNO_3 + HCl \rightleftharpoons$
2. $AgCl + H_2O \text{ (hot)} \rightleftharpoons$
3. $AgCl + NH_4OH \rightleftharpoons$
4. $(NH_3)_3(AgCl)_2 + HNO_3 \rightleftharpoons$
5. $AgCl \text{ exposed to light} \rightleftharpoons$

MERCURY Hg^I

1. $HgNO_3 + HCl \rightleftharpoons$
2. $HgCl + H_2O \text{ (hot)} \rightleftharpoons$
3. $HgCl + NH_4OH \rightleftharpoons \underline{NH_2HgCl} +$
4. $NH_2.HgCl + Hg + \text{aqua regia} \rightleftharpoons HgCl_2 + NH_4Cl + NO + H_2O$
 write (4) in two steps thus—
 a) $NH_2.HgCl + Hg + HCl \rightleftharpoons HgCl_2 + NH_4Cl + H_2$
 b) $HNO_3 + H_2 \rightleftharpoons NO + H_2O$

GROUP II.

SUB-GROUP A.

MERCURY Hg^{II}

1. $\text{HgCl}_2 + \text{H}_2\text{S} \rightleftharpoons$
2. $\text{HgS} + \text{HNO}_3 \text{ (dilute)} \rightleftharpoons$
3. $\text{HgS} + \text{aqua regia} \rightleftharpoons \text{HgCl}_2 + \text{NO} + \text{S} + \text{H}_2\text{O}$
(Write on same principle as 4 under Mercurous salts).
4. $\text{HgCl}_2 + \text{SnCl}_2 \rightleftharpoons$

LEAD Pb^{II}

1. $\text{PbCl}_2 + \text{H}_2\text{S} \rightleftharpoons$
2. $\text{PbS} + \text{HNO}_3 \rightleftharpoons \text{Pb}(\text{NO}_3)_2 + \text{NO} + \text{S} + \text{H}_2\text{O}$
Complete the above by combining the two following equations (a and b)
 - a) $\text{PbS} + \text{HNO}_3 \rightleftharpoons \text{Pb}(\text{NO}_3)_2 + \text{H}_2\text{S}$
 - b) $\text{H}_2\text{S} + \text{HNO}_3 \rightleftharpoons \text{NO} + \text{S} + \text{H}_2\text{O}$
3. $\text{Pb}(\text{NO}_3)_2 + \text{H}_2\text{SO}_4 \rightleftharpoons$
4. $\text{PbSO}_4 + (\text{NH}_4)_2(\text{C}_4\text{H}_4\text{O}_6)$ form probably a soluble, double salt
5. $\text{PbSO}_4 + \text{K}_2\text{Cr}_2\text{O}_7 \rightleftharpoons \underline{\text{PbCrO}_4} +$

BISMUTH Bi^{III}

1. $\text{BiCl}_3 + \text{H}_2\text{O} \rightleftharpoons$
2. $\text{BiOCl} + \text{H}_2\text{S} \rightleftharpoons$
3. $\text{Bi}_2\text{S}_3 + \text{HNO}_3 \rightleftharpoons$
4. $\text{Bi}(\text{NO}_3)_3 + \text{H}_2\text{SO}_4 \rightleftharpoons$
5. $\text{Bi}_2(\text{SO}_4)_3 + \text{NH}_4\text{OH} \rightleftharpoons$
6. $\text{Bi}(\text{OH})_3 + \text{HCl} \rightleftharpoons$
7. $\text{BiCl}_3 + \text{H}_2\text{O} \rightleftharpoons$

COPPER Cu^{II}

1. $\text{CuSO}_4 + \text{H}_2\text{S} \rightleftharpoons$
2. $\text{CuS} + \text{HNO}_3 \rightleftharpoons$
3. $\text{Cu}(\text{NO}_3)_2 + \text{H}_2\text{SO}_4 \rightleftharpoons$
4. $\text{CuSO}_4 + \text{NH}_4\text{OH} \rightleftharpoons$
5. $\text{CuSO}_4 \cdot 4\text{NH}_3 + \text{HCl} \rightleftharpoons$
6. $\text{CuSO}_4 + \text{Fe} \rightleftharpoons$

CADMIUM Cd^{II}

1. $\text{Cd}(\text{NO}_3)_2 + \text{H}_2\text{S} \rightleftharpoons$
2. $\text{CdS} + \text{HNO}_3 \rightleftharpoons$
3. $\text{Cd}(\text{NO}_3)_2 + \text{H}_2\text{SO}_4 \rightleftharpoons$
4. $\text{CdSO}_4 + \text{NH}_4\text{OH} \rightleftharpoons$
5. $\text{Cd}(\text{OH})_2 + \text{HCl} \rightleftharpoons$
6. $\text{CdCl}_2 + \text{Fe} \rightleftharpoons$
7. $\text{CdCl}_2 + \text{H}_2\text{S} \rightleftharpoons$

SUB-GROUP B.

ARSENIC As^{III}

1. $\text{As}_2\text{O}_3 + \text{H}_2\text{S} \rightleftharpoons$
2. $\text{As}_2\text{S}_3 + (\text{NH}_4)_2\text{S} \rightleftharpoons$
3. $(\text{NH}_4)_3\text{AsS}_3 + \text{HCl} \rightleftharpoons \text{NH}_4\text{Cl} + \underline{\text{As}_2\text{S}_5} +$
4. $\text{As}_2\text{S}_3 + (\text{Conc.}) \text{HCl} \rightleftharpoons$
5. $\text{As}_2\text{S}_3 + \text{KClO}_3 + \text{HCl} + \text{H}_2\text{O} \rightleftharpoons \text{H}_3\text{AsO}_4 + \text{KCl} + \text{HCl} + \text{S}$

thus :

- a) $\text{KClO}_3 + \text{HCl} \rightleftharpoons$
- b) $\text{HClO}_3 \rightleftharpoons \text{HCl} + \text{O}$
- c) $\text{As}_2\text{S}_3 + \text{O} + \text{H}_2\text{O} \rightleftharpoons \text{H}_3\text{AsO}_4 + \text{S}$
6. $\text{H}_3\text{AsO}_4 + \text{MgSO}_4 + \text{NH}_4\text{OH} \rightleftharpoons$

ARSENIC As^{V}

1. $\text{H}_3\text{AsO}_4 + \text{H}_2\text{S} \rightleftharpoons$
2. $\text{As}_2\text{O}_3 + \text{K}_2\text{Cr}_2\text{O}_7 + \text{HCl} + \text{H}_2\text{O} \rightleftharpoons \text{H}_3\text{AsO}_4 + \text{CrCl}_3 + \text{KCl}$
3. $\text{H}_3\text{AsO}_4 + \text{MgSO}_4 + \text{NH}_4\text{OH} \rightleftharpoons$

TIN Sn^{II}

1. $\text{SnCl}_2 + \text{H}_2\text{S} \rightleftharpoons$
2. $\text{SnS} + (\text{NH}_4)_2\text{S}_2 \rightleftharpoons$

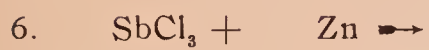
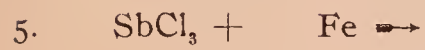
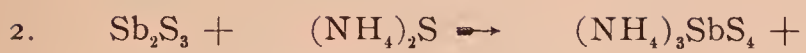
Precipitate finally dissolves

3. $(\text{NH}_4)_2\text{S} + \text{SnS}_2 + \text{HCl} \rightleftharpoons$
4. $\text{SnS}_2 + (\text{Conc.}) \text{HCl} \rightleftharpoons$
5. $\text{SnCl}_4 + \text{Fe} \rightleftharpoons$
6. $\text{SnCl}_2 + \text{HgCl}_2 \rightleftharpoons$

TIN Sn^{IV}



ANTIMONY Sb^{III}



GROUP III.

CHROMIUM Cr^{III}

1. $\text{K}_2\text{Cr}_2(\text{SO}_4)_4 + \text{NH}_4\text{OH} \rightleftharpoons$
2. $\text{Cr}(\text{OH})_3 + \text{HCl} \rightleftharpoons$
3. $\text{CrCl}_3 + \text{BaCO}_3 + \text{H}_2\text{O} \rightleftharpoons \underline{\text{Cr}(\text{OH})\text{CO}_3} +$
4. $\text{Cr}(\text{OH})\text{CO}_3 + \text{NaOH} \rightleftharpoons$
5. $\text{Cr}(\text{OH})_3 + \text{Na}_2\text{CO}_3 + \text{KClO}_3 + \text{H}_2\text{O} \rightleftharpoons \text{K}_2\text{CrO}_4 + \text{NaCl} +$
 $\text{H}_2\text{O} + \text{CO}_2 + \text{O}$
6. $\text{K}_2\text{Cr}_2\text{O}_7 + \text{HCl} + \text{H}_2\text{S} \rightleftharpoons \text{CrCl}_3 + \text{KCl} + \text{S} + \text{H}_2\text{O}$

ALUMINUM Al^{III}

1. $\text{K}_2\text{Al}_2(\text{SO}_4)_4 + \text{NH}_4\text{OH} \rightleftharpoons$
2. $\text{Al}(\text{OH})_3 + (\text{NH}_4)_2\text{S} \rightleftharpoons$
3. $\text{Al}(\text{OH})_3 + \text{HCl} \rightleftharpoons$
4. $\text{AlCl}_3 + \text{BaCO}_3 + \text{H}_2\text{O} \rightleftharpoons \underline{\text{Al}(\text{OH})_3} + \underline{\text{Al}(\text{OH})\text{CO}_3} +$
5. $\text{Al}(\text{OH})_3 + \text{Na}(\text{OH}) \rightleftharpoons$
6. $\text{Na}_3\text{AlO}_3 + \text{HCl} \rightleftharpoons$
7. $\text{AlCl}_3 + \text{NH}_4\text{OH} \rightleftharpoons$

IRON Fe^{II} AND Fe^{III}

1. $\text{FeCl}_3 + \text{NH}_4\text{OH} \rightleftharpoons$
2. $\text{Fe}(\text{OH})_3 + (\text{NH}_4)_2\text{S} \rightleftharpoons \underline{\text{FeS}} +$
3. $\text{FeS} + \text{HCl} \rightleftharpoons$
4. $\text{FeCl}_2 + \text{HNO}_3 + \text{HCl} \rightleftharpoons \text{FeCl}_3 + \text{NO} + \text{H}_2\text{O}$
5. $\text{FeCl}_3 + \text{KCNS} \rightleftharpoons$
6. $\text{FeCl}_3 + \text{K}_4(\text{Fe}(\text{CN})_6) \rightleftharpoons$
7. $\text{FeCl}_3 + \text{BaCO}_3 + \text{H}_2\text{O} \rightleftharpoons \underline{\text{Fe}_2\text{O}(\text{CO}_3)_2} +$

1. $\text{FeSO}_4 + \text{KCNS} \rightleftharpoons$
2. $\text{Fe}_2(\text{SO}_4)_3 + \text{KCNS} \rightleftharpoons$
3. $\text{Fe}(\text{SO}_4) + \text{K}_4(\text{Fe}(\text{CN})_6) \rightleftharpoons$
4. $\text{Fe}_2(\text{SO}_4)_3 + \text{K}_4(\text{Fe}(\text{CN})_6) \rightleftharpoons$
5. $\text{FeSO}_4 + \text{K}_3(\text{Fe}(\text{CN})_6) \rightleftharpoons$
6. $\text{Fe}_2(\text{SO}_4)_3 + \text{K}_3(\text{Fe}(\text{CN})_6) \rightleftharpoons$
7. $\text{FeSO}_4 + \text{NaOH} \rightleftharpoons$
8. $\text{Fe}_2(\text{SO}_4)_3 + \text{NaOH} \rightleftharpoons$
9. $\text{FeSO}_4 + \text{H}_2\text{SO}_4 + \text{HNO}_3 \rightleftharpoons$
10. $\text{Fe}_2(\text{SO}_4)_3 + \text{H}_2\text{S} \rightleftharpoons$

COBALT Co^{II}

1. $\text{Co}(\text{NO}_3)_2 + \text{NH}_4\text{Cl} + \text{NH}_4\text{OH} \rightleftharpoons$
2. $\text{Co}(\text{NO}_3)_2 + (\text{NH}_4)_2\text{S} \rightleftharpoons$
3. $\text{CoS} + (\text{dil.})\text{HCl} \rightleftharpoons$
4. $\text{CoS} + \text{aqua regia} \rightleftharpoons$
(see mercury)
5. $\text{CoCl}_2 + \text{NaOH} \rightleftharpoons$
6. $\text{Co}(\text{OH})_2 + \text{H}(\text{C}_2\text{H}_3\text{O}_2) \rightleftharpoons$
7. $\text{Co}(\text{C}_2\text{H}_3\text{O}_2)_2 + \text{KNO}_2 + \text{H}(\text{C}_2\text{H}_3\text{O}_2) + \text{H}_2\text{O} \rightleftharpoons \underline{(\text{KNO}_2)_3 \cdot \text{Co}(\text{NO}_2)_3 \cdot 2\text{H}_2\text{O}} +$
 $\text{K}(\text{C}_2\text{H}_3\text{O}_2) + \text{NO}$
8. Cobalt compounds in borax bead \rightleftharpoons color

NICKEL Ni^{II}

1. $\text{Ni}(\text{NO}_3)_2 + \text{NH}_4\text{Cl} + \text{NH}_4\text{OH} \rightleftharpoons$
2. $\text{Ni}(\text{NO}_3)_2 + (\text{NH}_4)_2\text{S} \rightleftharpoons$
3. $\text{NiS} + \text{dil. HCl} \rightleftharpoons$
4. $\text{NiS} + \text{aqua regia} \rightleftharpoons$
(see mercury)
5. $\text{NiCl}_2 + \text{NaOH} \rightleftharpoons$
6. $\text{Ni}(\text{OH})_2 + \text{H}(\text{C}_2\text{H}_3\text{O}_2) \rightleftharpoons$
7. $\text{Ni}(\text{C}_2\text{H}_3\text{O}_2)_2 + \text{KNO}_2 \rightleftharpoons$
8. $\text{Ni}(\text{C}_2\text{H}_3\text{O}_2)_2 + \text{NaOH} \rightleftharpoons$
9. Nickel compounds in borax bead \rightleftharpoons color

MANGANESE Mn^{II}

1. $\text{MnSO}_4 + \text{NH}_4\text{Cl} + \text{NH}_4\text{OH} \rightleftharpoons$
2. $\text{MnSO}_4 + (\text{NH}_4)_2\text{S} \rightleftharpoons$
3. $\text{MnS} + \text{HCl} \rightleftharpoons$
4. $\text{MnCl}_2 + \text{BaCO}_3 \rightleftharpoons$
5. $\text{MnCl}_2 + (\text{NH}_4)_2\text{S} \rightleftharpoons$
6. $\text{MnCl}_2 + \text{NaOH} \rightleftharpoons$
7. $\text{Mn}(\text{OH})_2 + \text{Na}_2\text{CO}_3 + \text{KNO}_3 \rightleftharpoons \text{K}_2\text{MnO}_4 + \text{Na}_2\text{MnO}_4 + \text{NO} +$
 $\text{CO}_2 + \text{H}_2\text{O}$

ZINC Zn^{II}

1. $\text{ZnSO}_4 + (\text{NH}_4\text{Cl}) + \text{NH}_4\text{OH} \rightleftharpoons$
2. $\text{ZnSO}_4 + (\text{NH}_4)_2\text{S} \rightleftharpoons$
3. $\text{ZnS} + \text{HCl} \rightleftharpoons$
4. $\text{ZnCl}_2 + \text{BaCO}_3 \rightleftharpoons$
5. $\text{ZnCl}_2 + (\text{NH}_4)_2\text{S} \rightleftharpoons$
6. $\text{ZnCl}_2 + \text{NaOH} \rightleftharpoons \text{ZnO}_2\text{Na}_2$
7. $\text{ZnO}_2\text{Na}_2 + \text{H}_2\text{S} \rightleftharpoons$

GROUP IV.

1. $\text{BaCl}_2 + (\text{NH}_4)_2\text{CO}_3 \rightleftharpoons$
2. $\text{BaCO}_3 + \text{H}(\text{C}_2\text{H}_3\text{O}_2) \rightleftharpoons$
3. $\text{Ba}(\text{C}_2\text{H}_3\text{O}_2)_2 + \text{CaSO}_4 \rightleftharpoons$
4. $\text{Ba}(\text{C}_2\text{H}_3\text{O}_2)_2 + \text{K}_2\text{Cr}_2\text{O}_7 \rightleftharpoons \text{BaCrO}_4$
5. $\text{BaCrO}_4 + \text{HCl} \rightleftharpoons$
6. $\text{BaCl}_2 + \text{H}_2\text{SO}_4 \rightleftharpoons$

STRONTIUM Sr^{II}

1. $\text{SrCl}_2 + (\text{NH}_4)_2\text{CO}_3 \rightleftharpoons$
2. $\text{SrCO}_3 + \text{H}(\text{C}_2\text{H}_3\text{O}_2) \rightleftharpoons$
3. $\text{Sr}(\text{C}_2\text{H}_3\text{O}_2)_2 + \text{CaSO}_4 \rightleftharpoons$
4. $\text{Sr}(\text{C}_2\text{H}_3\text{O}_2)_2 + \text{K}_2\text{Cr}_2\text{O}_7 \rightleftharpoons$
5. $\text{Sr}(\text{C}_2\text{H}_3\text{O}_2)_2 + (\text{NH}_4)_2\text{CO}_3 \rightleftharpoons$
6. $\text{Sr}(\text{C}_2\text{H}_3\text{O}_2)_2 + (\text{NH}_4)_2\text{SO}_4 \rightleftharpoons$

CALCIUM Ca^{II}

1. $\text{CaCl}_2 + (\text{NH}_4)_2\text{CO}_3 \rightleftharpoons$
2. $\text{CaCO}_3 + \text{H}(\text{C}_2\text{H}_3\text{O}_2) \rightleftharpoons$
3. $\text{Ca}(\text{C}_2\text{H}_3\text{O}_2)_2 + \text{CaSO}_4 \rightleftharpoons$
4. $\text{Ca}(\text{C}_2\text{H}_3\text{O}_2)_2 + \text{K}_2\text{Cr}_2\text{O}_7 \rightleftharpoons$
5. $\text{Ca}(\text{C}_2\text{H}_3\text{O}_2)_2 + (\text{NH}_4)_2\text{CO}_3 \rightleftharpoons$
6. $\text{Ca}(\text{C}_2\text{H}_3\text{O}_2)_2 + (\text{NH}_4)_2\text{SO}_4 \rightleftharpoons$
7. $\text{CaSO}_4 + (\text{NH}_4)_2\text{C}_2\text{O}_4 \rightleftharpoons$

GROUP V.

MAGNESIUM Mg^{II}

1. $\text{MgCl}_2 + \text{NH}_4\text{OH} + \text{Na}_2\text{HPO}_4 \rightleftharpoons \text{MgNH}_4\text{PO}_4 +$
2. $\text{MgCl}_2 + \text{Ba}(\text{OH})_2 \rightleftharpoons$

SODIUM Na^{I}

1. Flame color of sodium
2. Flame color of sodium and potassium

POTASSIUM K^{I}

1. Flame color of potassium
2. $\text{KCl} + \text{H}_2\text{PtCl}_6 \rightleftharpoons$

AMMONIUM NH_4^{I}

1. $\text{NH}_4\text{Cl} + \text{H}_2\text{PtCl}_6 \rightleftharpoons$
2. $\text{NH}_4\text{Cl} + \text{NaOH} \rightleftharpoons$

PRELIMINARY EXAMINATION

		RESULT	INDICATION
1.	Heating in a closed tube.		
2.	Heated with conc. H_2SO_4		
3.	Heated on charcoal.		
4.	Heated on charcoal with Na_2CO_3		
5.	Flame test		
6.	Borax bead in O. F.		
7.	Solution.		

RECORD OF ANALYSIS

ACID RADICALS

GR. I	GR. II *	GR. III *	GR. IV *
Boiling with dilute HCl or HNO ₃ decomposes	CaCl ₂ precipitates	BaCl ₂ precipitates	ZnCl ₂ precipitates
GR. V *	GR. VI †	GR. VII	GR. VIII
Ferric chloride gives red color	Silver nitrate precipitates	Not precipitated	Carbonizes on heating
*Use neutral solution.			
†Use dilute acid solution.			

Special Tests for Acids

Special Tests for Acids (Continued)

CONCLUSION

PRELIMINARY EXAMINATION

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[illegible]

Special Tests for Acids

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RECORD OF ANALYSIS

ACID RADICALS

[illegible]

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RECORD OF ANALYSIS

ACID RADICALS

[illegible]

Special Tests for Acids

Special Tests for Acids (Continued)

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RECORD OF ANALYSIS

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[illegible]

Special Tests for Acids

Special Tests for Acids (Continued)

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RECORD OF ANALYSIS

ACID RADICALS

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Special Tests for Acids

Special Tests for Acids (Continued)

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RECORD OF ANALYSIS

ACID RADICALS

GR. I	GR. II *	GR. III *	GR. IV *
Boiling with dilute HCl or HNO ₃ decomposes	CaCl ₂ precipitates	BaCl ₂ precipitates	ZnCl ₂ precipitates
GR. V *	GR. VI †	GR. VII	GR. VIII
Ferric chloride gives red color	Silver nitrate precipitates	Not precipitated	Carbonizes on heating

*Use neutral solution.
†Use dilute acid solution.

Special Tests for Acids

Special Tests for Acids (Continued)

CONCLUSION

PRELIMINARY EXAMINATION

	RESULT	INDICATION
1. Heating in a closed tube.		
2. Heated with conc. H_2SO_4		
3. Heated on charcoal.		
4. Heated on charcoal with Na_2CO_3		
5. Flame test		
6. Borax bead in O. F.		
7. Solution.		

RECORD OF ANALYSIS

ACID RADICALS

[illegible]

Special Tests for Acids

Special Tests for Acids (Continued)

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RECORD OF ANALYSIS

ACID RADICALS

[illegible]

Special Tests for Acids

Special Tests for Acids (Continued)

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ACID RADICALS

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Special Tests for Acids (Continued)

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ACID RADICALS

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ACID RADICALS

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Special Tests for Acids

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ACID RADICALS

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Special Tests for Acids

Special Tests for Acids (Continued)

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ACID RADICALS

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Special Tests for Acids

Special Tests for Acids (Continued)

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ACID RADICALS

[illegible]

Special Tests for Acids

Special Tests for Acids (Continued)

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ACID RADICALS

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Special Tests for Acids (Continued)

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RECORD OF ANALYSIS

ACID RADICALS

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Special Tests for Acids

Special Tests for Acids (Continued)

CONCLUSION

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